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B1C CPJA C122 C2011
B7V VAA VBJ V101 V102 V129 V136

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EP 0196764 A1 **EP 0181135 A2** **US 4028009 A**

(58) Field of Search
UK CL (Edition O) **F1E**
INT CL^6 **F04F 5/00 5/02 5/10 5/12 5/24 5/26 5/42 5/44 5/46**

(54) **Improvements in or relating to jet pumps**

(57) A jet pump consists of a central passageway (11) surrounded by an annular member (2) through which holes (10) are provided, both at an angle to the axis (24) of the passageway and at an angle to respective radial planes, so that when a fluid is ejected through the holes its momentum drives forward the material in the passageway thereby generating a pumping action. The pump has many uses including the transfer of fluids, suspensions of a solid in a fluid or granular solids; the mixing of a fluid with another substance; aeration; dilution. Two or more pumps may be used in parallel or series to provide an increased flow and/or head. By mounting two pumps back-to-back a backflushing facility is provided. A particular advantage of this type of pump is that, having no moving parts, it is suitable for location in inaccessible places such as submerged environments. Hence the discharge from a submerged pump may act as a source of motive power to move a structure attached thereto such as a stirrer in a large tank or a water borne craft.

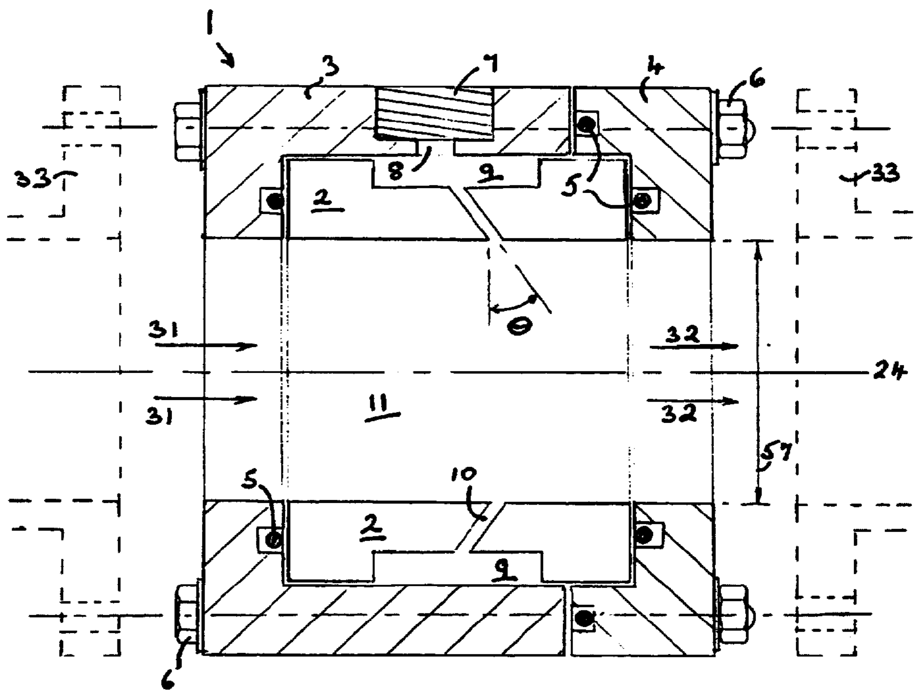

FIG. 1.

GB 2 313 410 A

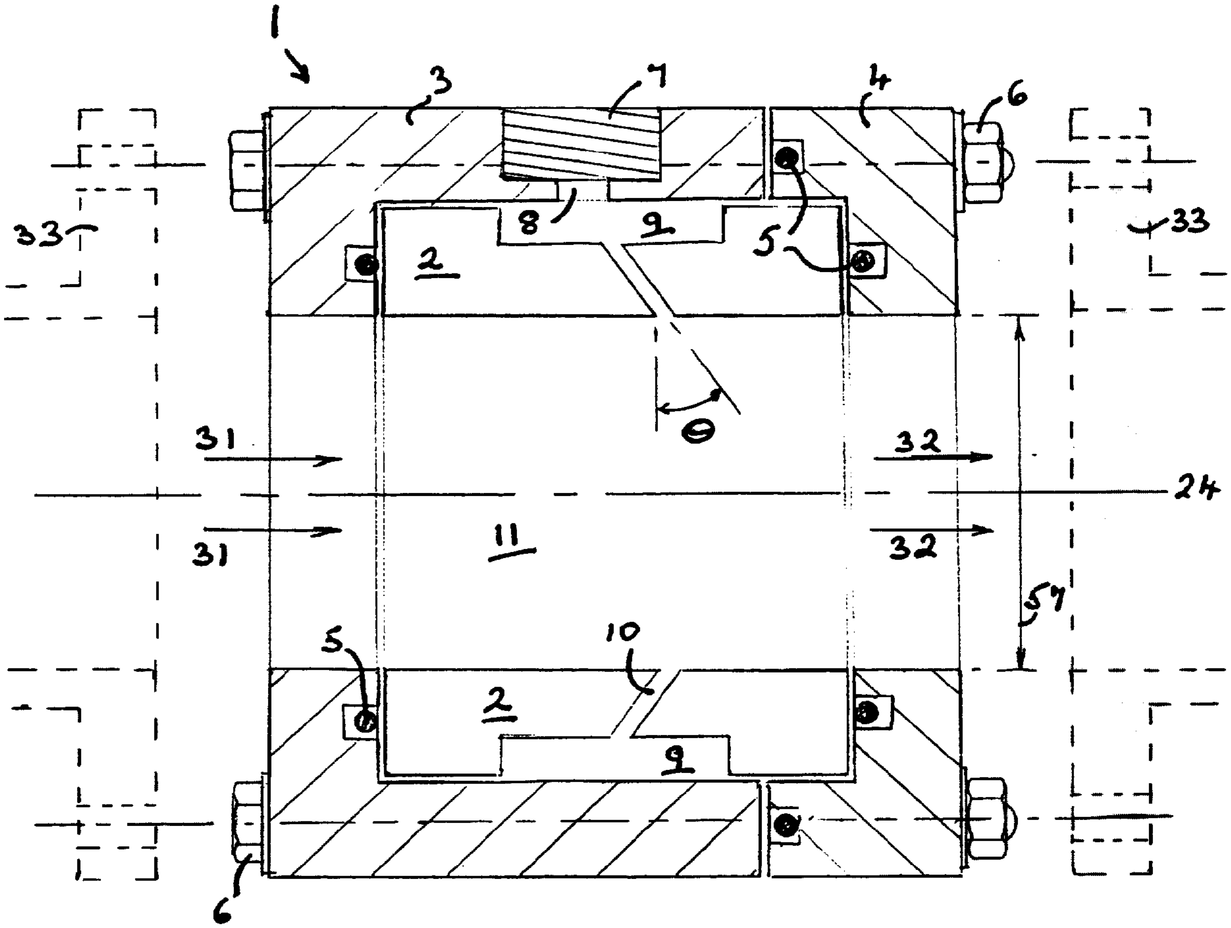

FIG. 1.

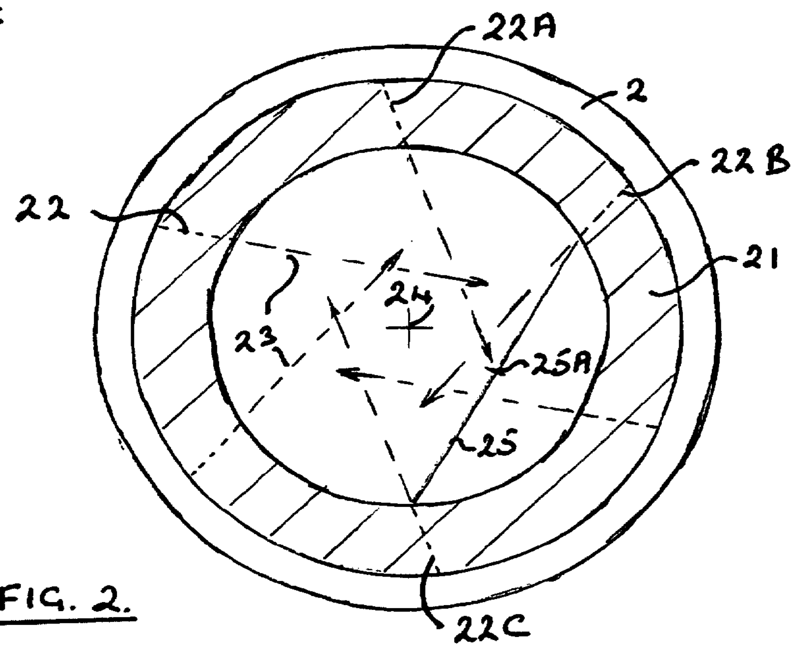

FIG. 2.

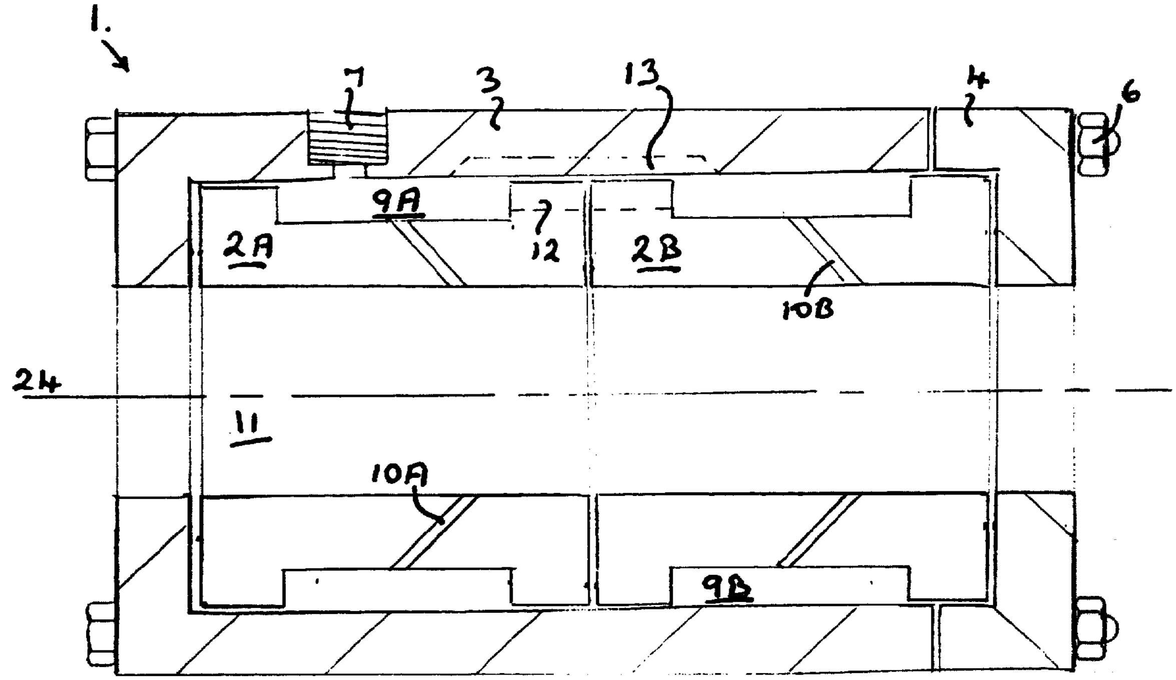
1.
7
3
13
4
6
9A
2A
12
2B
10B
24
11
10A
9B

FIG. 3

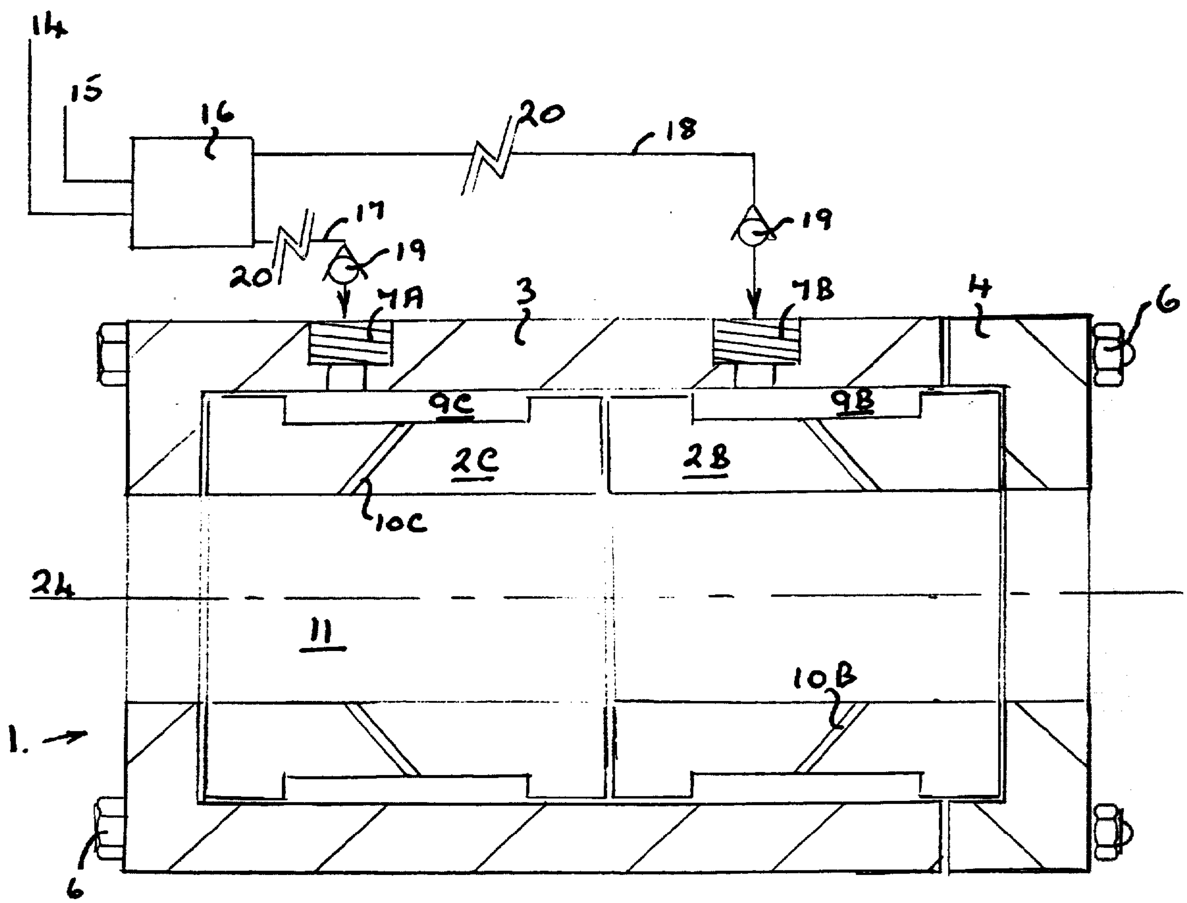
14
15
16
20
18
17
19
20
19
7A
3
7B
4
6
9C
9B
2C
2B
10C
24
11
10B
1.
6

FIG. 4

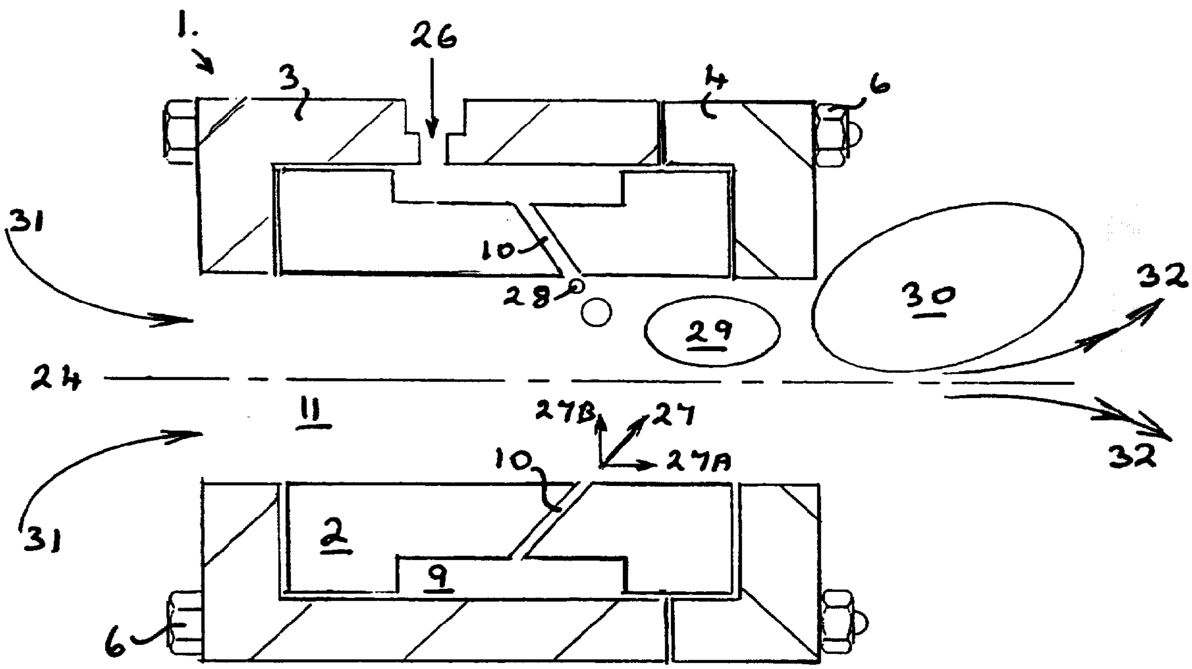
1.
26
3
4
6
31
10
28
29
30
32
24
11
27B
27
27A
10
2
9
6
31
32

FIG. 5.

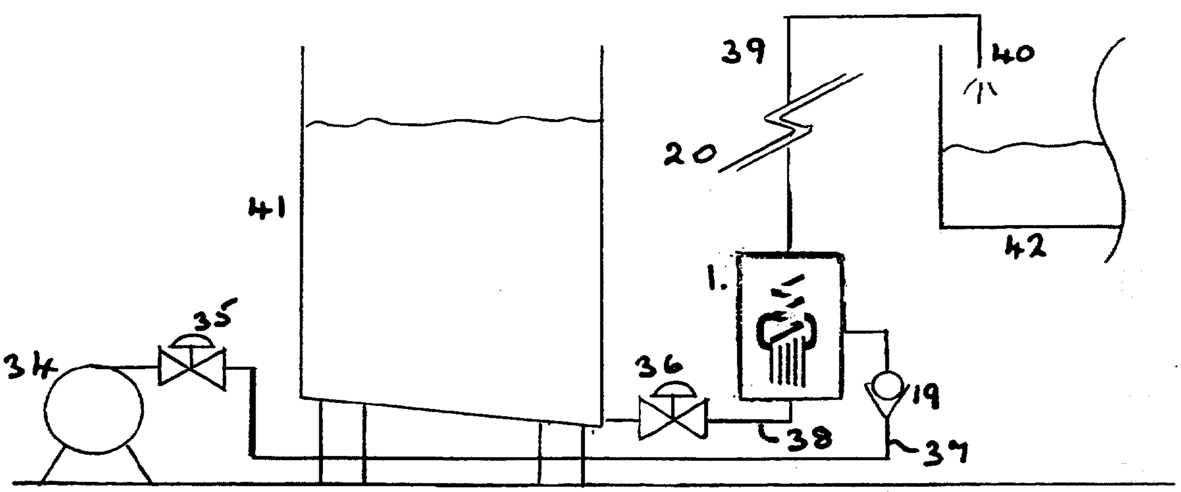
39
40
20
41
42
1.
35
34
36
19
38
37

FIG. 6.

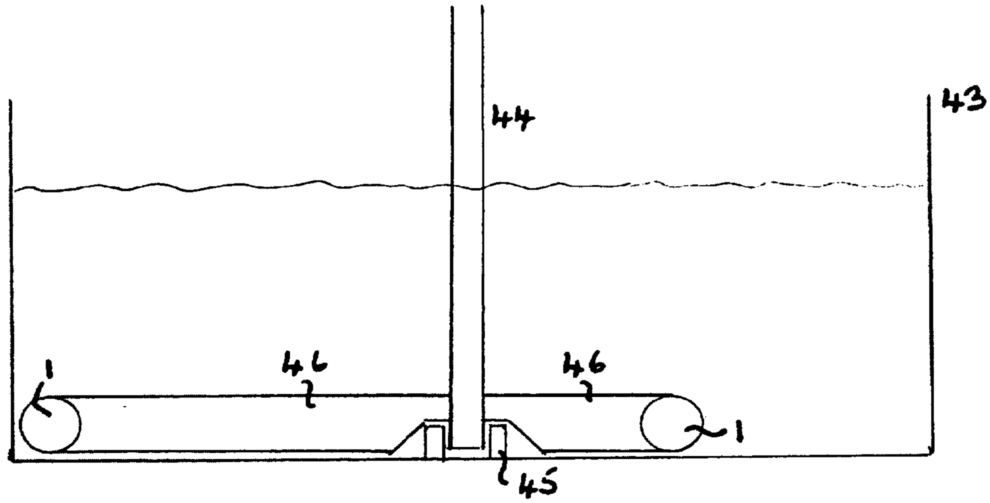

FIG. 7

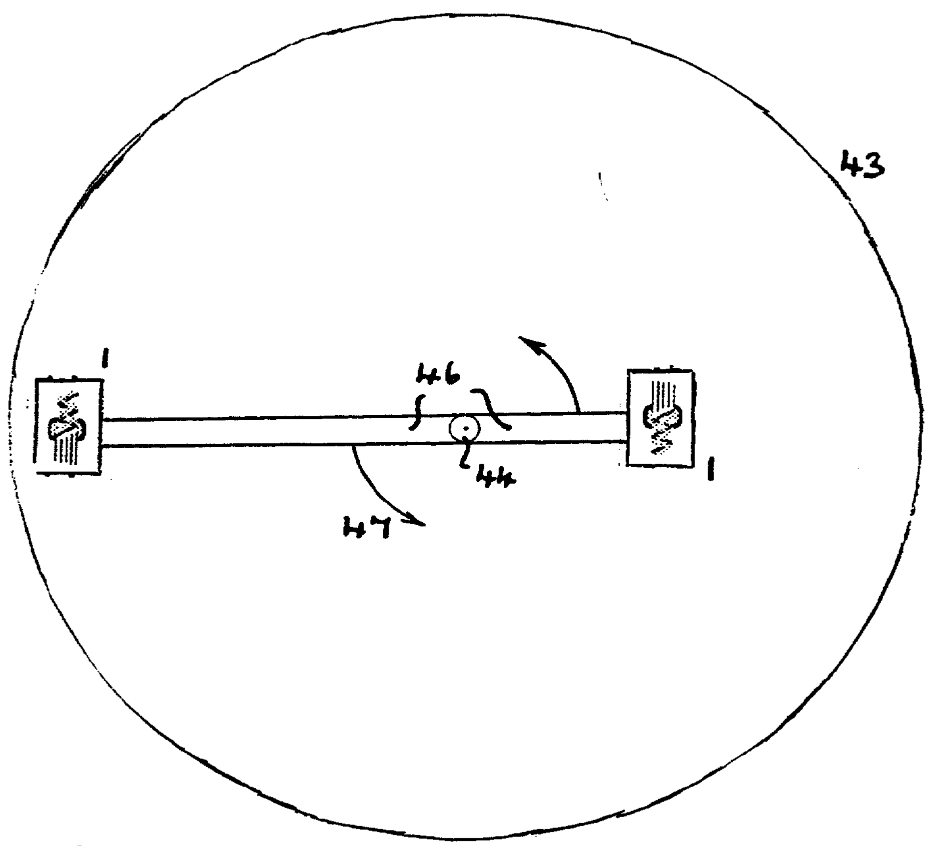

FIG. 8

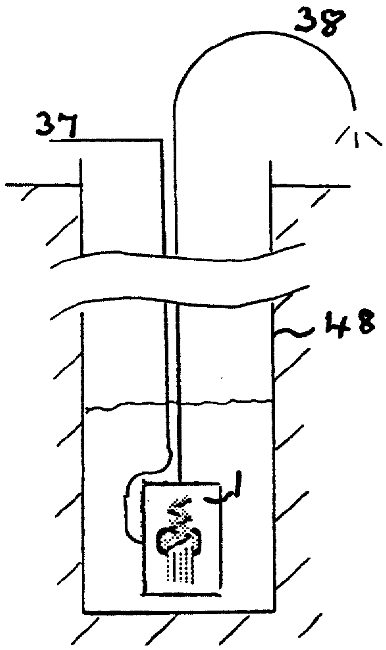

FIG. 9.

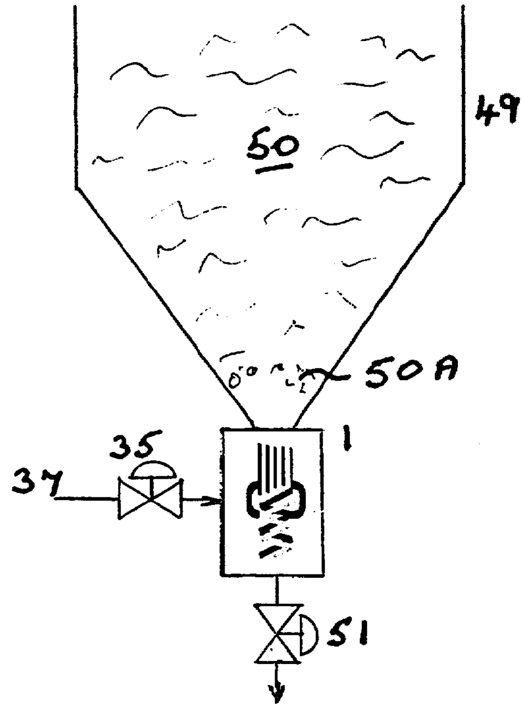

FIG. 10.

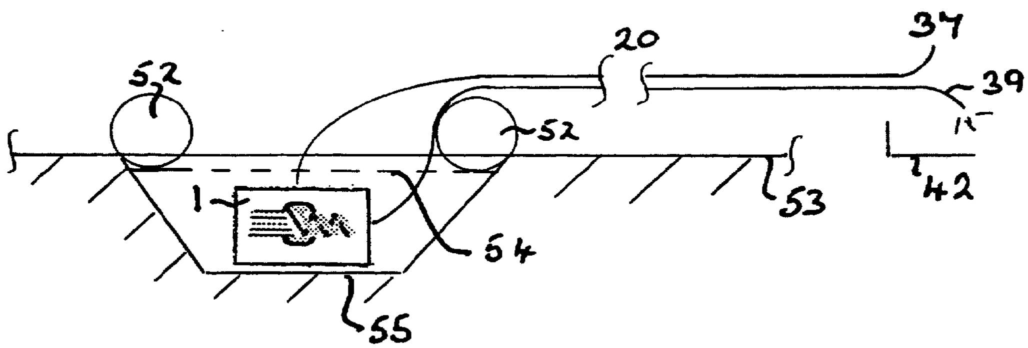

FIG. 11.

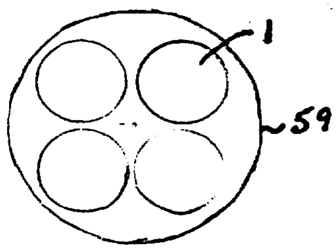

FIG. 12.

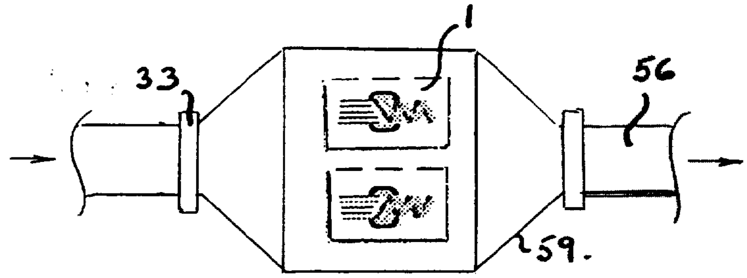

FIG. 13.

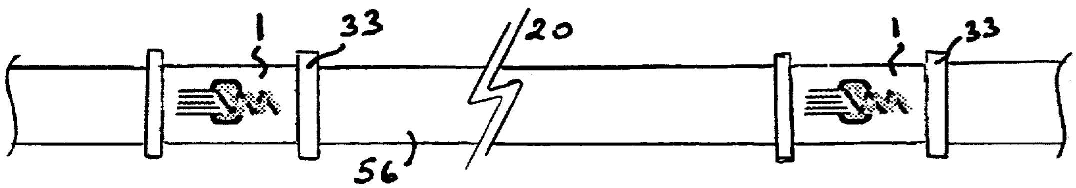

FIG. 14.

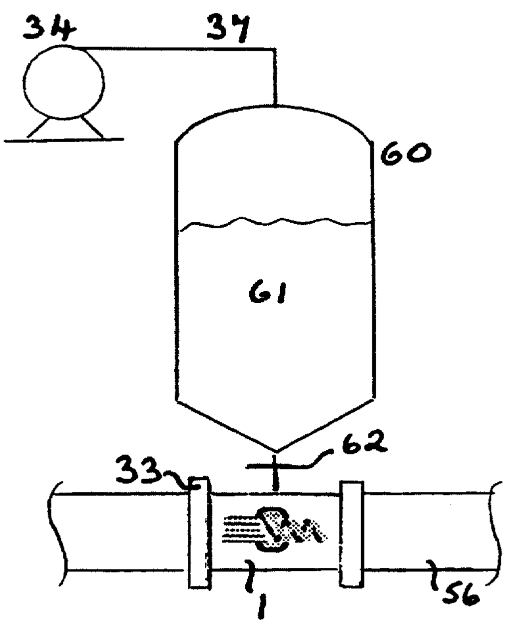

FIG. 15.

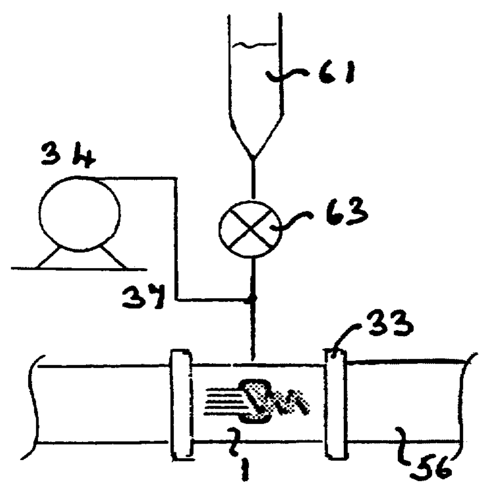

FIG. 16.

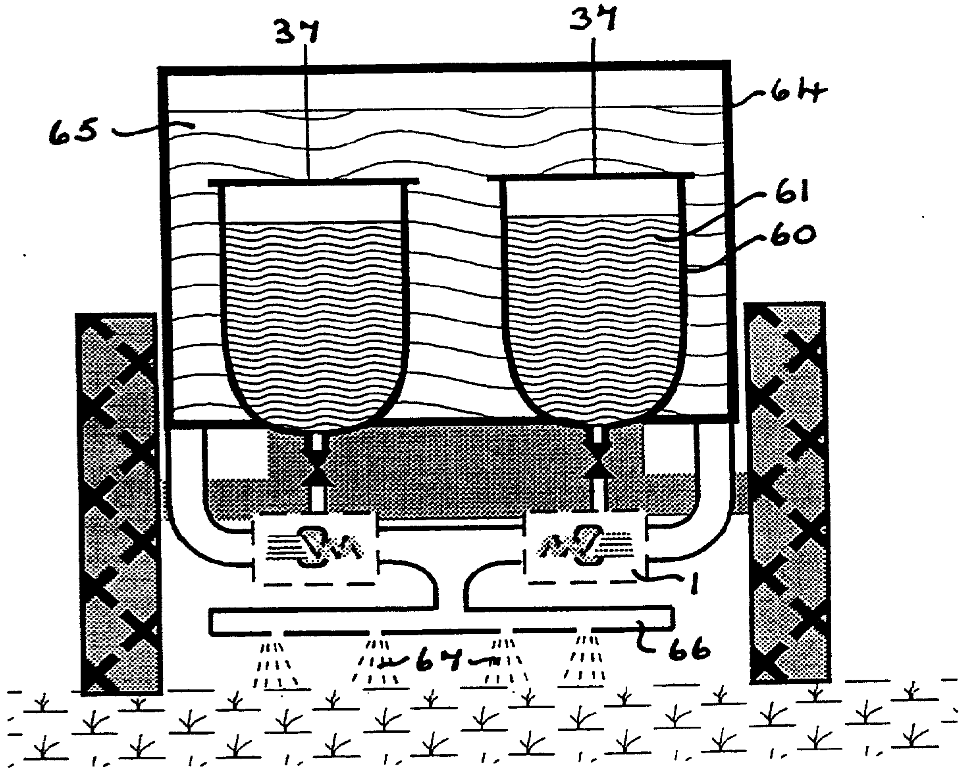

FIG. 17.

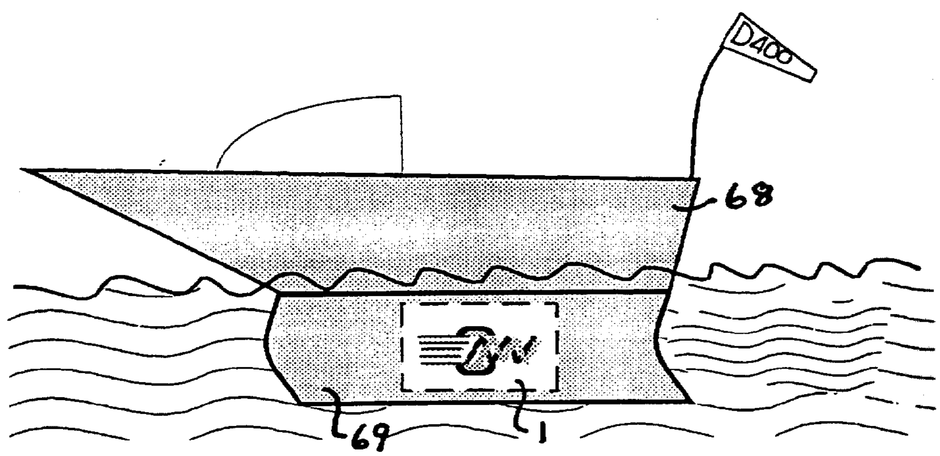

FIG. 18.

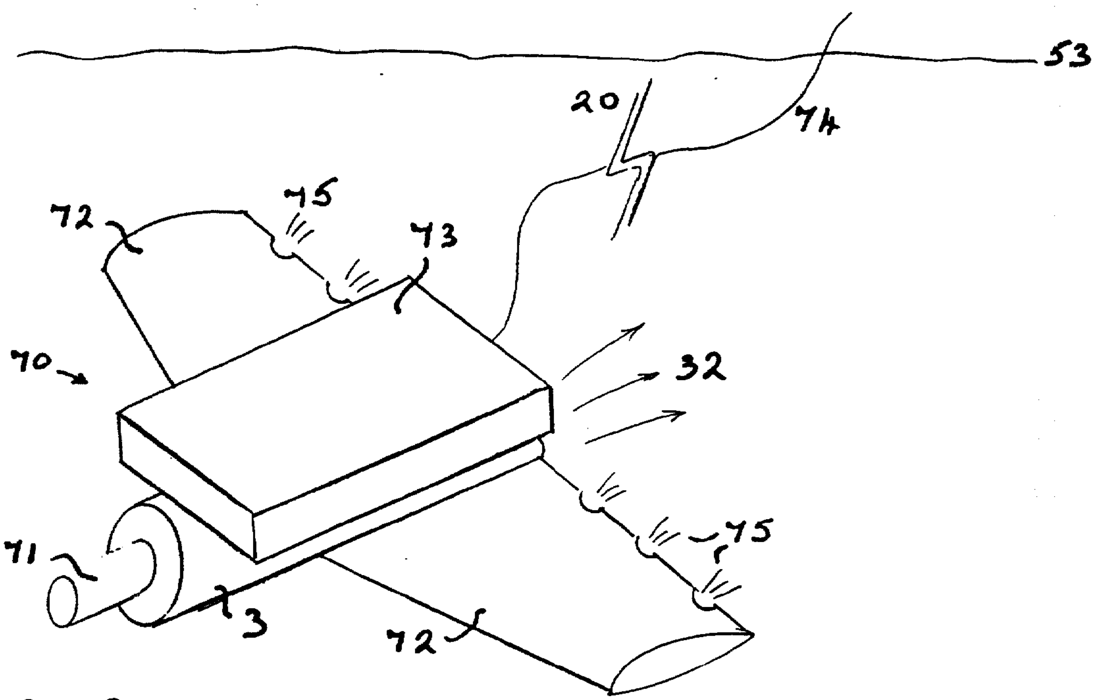

FIG. 19.

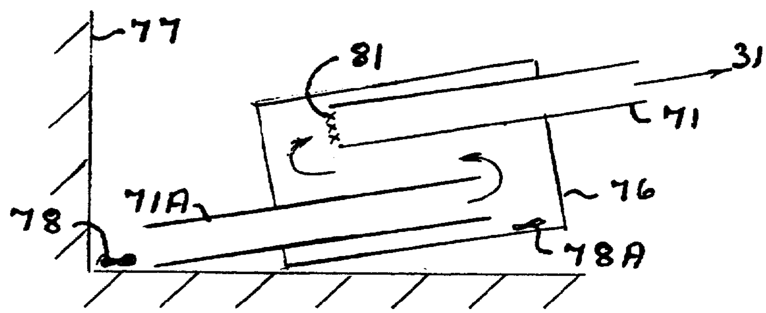

FIG. 20.

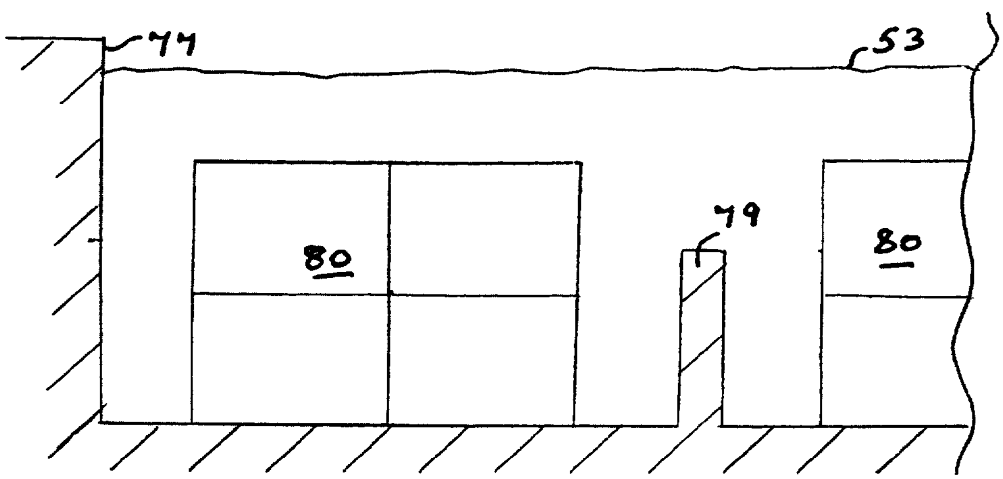

FIG. 21.

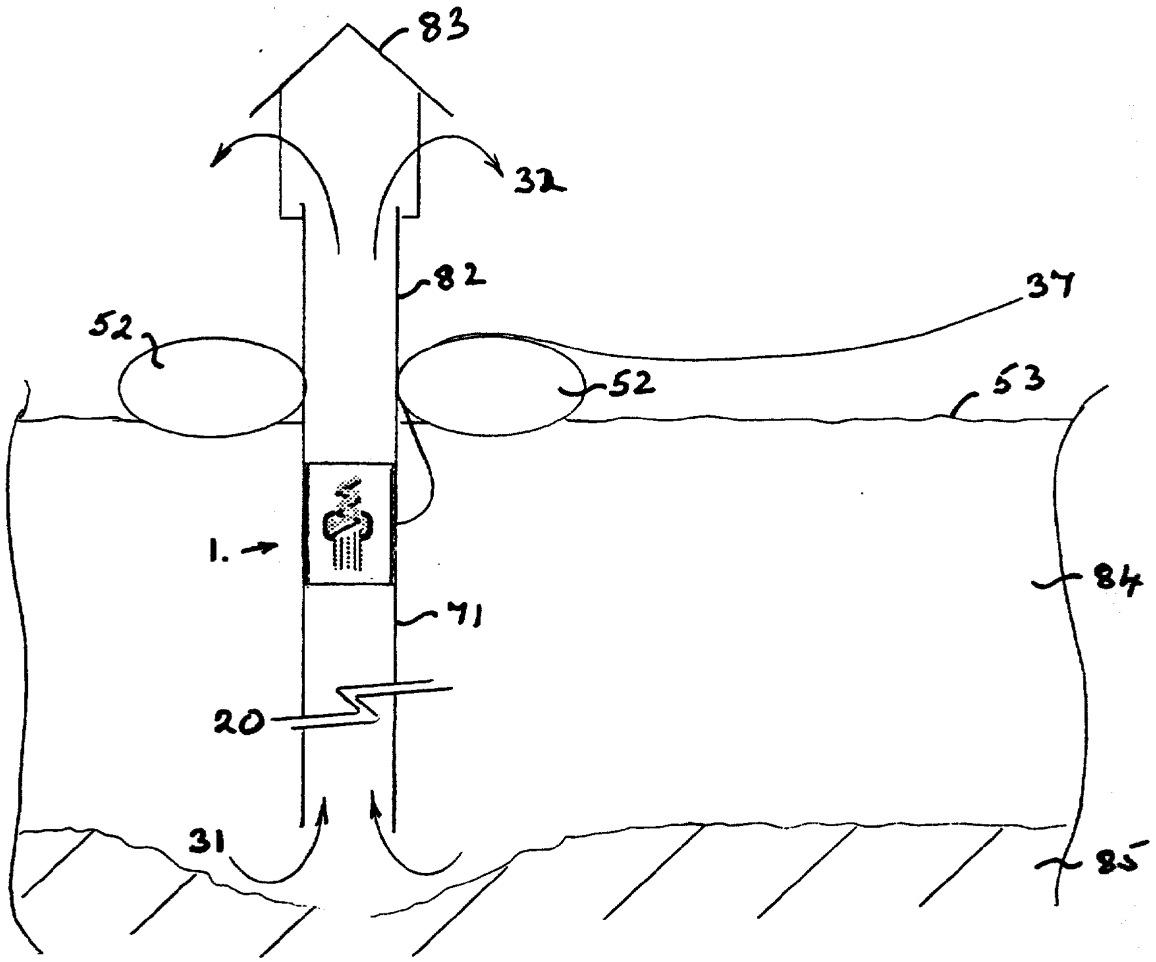

FIG. 22.

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IMPROVEMENTS IN OR RELATING TO PUMPS

This specification relates to the use of 'Fluidic Principles' to provide the motive power for pumping single or multi-phase fluids or suspensions.

'Fluidic Motor' is used as the Trading Mark for apparatus according to the invention and this term is used hereinafter. The word 'Motor' is preferred because of the efficiency with which the material to be transferred is driven out of the apparatus by the fluidising medium but it will be apparent to those skilled in the art that the main process operations performed by the various forms of the apparatus of the invention are:-

- pumping of single and multi-phase fluids or suspensions; and
- provision of motive power to process substances or to the apparatus itself and components attached thereto.

Many varieties of pump are known, for example, centrifugal, positive displacement, gear, etc., but they all suffer from the problem of having moving components. This results in the need for a regular programme of skilled maintenance to adjust clearances, replace seals and worn components, etc. Also a means of primary power must be provided, for example, an electric motor, which will usually require some form of flexible coupling to the pump. Because of hydraulic factors, for example, the need to provide an inlet head to the pump, the motor-pump assembly is often located underneath tanks in areas which are relatively inaccessible, so that the maintenance tasks are more onerous than they might otherwise be. Often the pump and its prime mover has to be submerged, for example, pumps to draw water from deep wells or for ornamental fountains. In such cases, much higher quality sealing is required and the maintenance problems are appropriately increased.

There is thus a need for a pumping means which is virtually maintenance free and which can be located at the most convenient places in the pipe run, even if this makes the pump relatively inaccessible.

According to a first aspect of the invention, there is provided a fluidic motor comprising:-

i) a passageway having a longitudinal axis and having an inlet end and an outlet end;

ii) an annular member surrounding said passageway and having a plurality of bores extending through said annular member into said passageway, said bores being:-

a) inclined at an angle to said longitudinal axis of said passageway; and

b) inclined at an angle to a projected radius of said passageway; and

iii) means to pass a fluid through said bores and eject it into said passageway;

characterised in that the ejection of said fluid through said bores into said passageway causes material to be drawn into said passageway through said inlet end and be pumped out of said passageway through said outlet end.

According to a first variation of the first aspect of the invention, said annular member is incorporated in a housing.

According to a second variation of the first aspect of the invention, said annular member is incorporated in a housing adapted for connection to items of process equipment.

According to a third variation of the first aspect of the invention, said housing is connectable to piping flanges.

Preferably, the passageway has the form of a hollow cylinder and the apparatus of the invention is provided with a suitable housing so that it may be mounted, for example, in a pipeline or in a tank. Preferably the housing includes means to connect the fluidic motor into the piping run or to mount it in/on appropriate members. The means to provide the fluid to the plurality of bores may be via an annular chamber surrounding

the annular member and be accessible via a connection to the housing. The annular chamber may be provided as a part of the annular member or as a part of the housing.

The bores in the annular member are arranged so that they are angled both with respect to the longitudinal axis and to a projection of a radius, so that the fluid ejected therefrom causes a rotational motion to be generated axially along the passageway in the direction from the inlet end towards the outlet end. The momentum and turbulence caused by the fluid ejected from these bores creates a reduction in pressure at the inlet end of the passageway and an increased pressure at the outlet end of the passageway. This results in the material to be pumped being drawn in through the inlet end, mixed with the fluid and the mixture forced out of the outlet end.

This combination of pumping and mixing has many benefits. Firstly, it allows a substance to be transported from one location to another by admixing with an essentially unreactive fluid; the fluid may subsequently be separated from the substance, or not, as required. Secondly, it allows a substance and a fluid to be mixed together; this be can to facilitate a chemical reaction or as a simple dilution process. The substance may be a second fluid or a suspension of a solid in a fluid. Thirdly, it allows a free flowing solid to be mixed with a fluid. This could be used for dissolving the solid in a liquid or, if the fluid is a gas, for the transport of the solid as a fluidised suspension.

Fluidic motors according to the invention are intended to require only an absolute minimum of maintenance, usually only cleaning at the annual maintenance shutdown, and are thus constructed of high quality materials. These materials may be metallic or non-metallic in nature or combinations of both. The pumps or compressors used to provide the fluid for supply to the bores are separate items of equipment and may be sited in readily accessible locations.

According to a fourth variation of the first aspect of the invention, a plurality of annular members is incorporated in a single housing, all having said bores aligned in the same direction so that the combined pumping effect is additive.

According to a fifth variation of the first aspect of the invention, fluidic motors are arranged in parallel to provide increased volumetric flow with essentially the same head as that produced by a single fluidic motor.

According to a sixth variation of the first aspect of the invention, fluidic motors are arranged in series to give essentially the same flow rate generated by a single fluidic motor, but with an increased head.

Because of their simple construction with no moving parts, fluidic motors according to the invention may not have the same throughput, or generate the same head, as conventional pumps. Thus, it may be appropriate to use them in parallel, to generate a greater volumetric flow, and/or in series, to produce a greater head.

According to a second aspect of the invention, two of said annular members are incorporated into a single housing, said two annular members being arranged so that the angles of their said bores point in opposite directions with said bores of the first annular member aligned pointing towards said outlet end and said bores of said second annular member pointing towards said inlet end and separate means are provided to pass fluid through said bores of each of said annular members.

According to a first variation of the second aspect of the invention, separate means are provided to control the provision of fluid through said bores of said first and second annular members, said means being operable to pass fluid first to said first annular member and then to said second annular member.

According to a second variation of the second aspect of the invention, said means to control the provision of fluid to the two annular members is provided with a timing means so that the flow of fluid can be alternated between said two annular members on a predetermined basis.

In pumping operations, particularly when solids or slurries are being handled, total or partial blockages are not uncommon. The arrangement of two annular members 'back-to-back' enables one to be used as the normal pumping means in the forward direction and the second to be used for 'backflushing'. Preferably, timing means are provided to cause the flow of fluid to alternate between the two annular members so that, for example, flow is maintained in the 'pumping' mode for one minute and 'backflushing' is provided for five seconds, before reverting to the pumping mode. This arrangement is particularly useful in emptying granular solids from hoppers, where 'bridging' at the outlet is common.

According to a third aspect of the invention, the reaction from the efflux from said outlet of said fluidic motor is used to provide motive power to move said fluidic motor.

According to a first variation of the third aspect of the invention, said fluidic motor is attached to a member which is caused to move with said fluidic motor.

Because the efflux from the fluidic motor can be quite significant, it creates a reaction force on the motor itself. Thus, if the motor is not fixed, it will tend to move in opposition to the direction of the efflux. This property can be used if, for example, two fluidic motors are attached to opposite ends of a stirrer, so that the combined efflux from the two motors will cause the stirrer to rotate and thus stir the whole of a large tank. If the fluidic motor is mounted on a structure which is free to move, the efflux will cause the whole structure to move. Thus, for example, if the fluidic motor is attached underneath a boat, it will provide the motive power to drive the boat through the water. Such a means of propulsion could be very effective on weed-infested

waterways, where short lengths of weed would pass through the motor and backflushing could be used to clear blockages.

For a clearer understanding of the invention and to show how the same may be put into effect, reference will now be made, by way of example only, to the accompanying drawings in which:-

Figure 1 is a sectional elevation of a fluidic motor according to the invention

Figure 2 is a sectional elevation through the element 2 of the fluidic motor of Fig. 1 showing the arrangement of the fluidising jets.

Figure 3 is a sectional elevation of a fluidic motor comprising twin elements arranged in series.

Figure 4 is a sectional elevation of a fluidic motor in which the two elements 2B and 2C are arranged to pump in opposite directions.

Figure 5 is a sectional elevation of a fluidic motor showing the principal of operation.

Figure 6 is a flow diagram of the arrangement of a fluidic motor according to the invention transferring a liquid from a first tank to a second tank.

Figure 7 is a sectional elevation of two fluidic motors according to the invention driving a stirring means in a tank.

Figure 8 is a plan view of the stirring means shown in Fig. 7.

Figure 9 is a sectional elevation of a fluidic motor of the invention used to draw water from a deep well.

Figure 10 is a sectional elevation of the use of a fluidic motor according to the invention to transfer a granular solid from a hopper into a pipe.

Figure 11 is a sectional elevation showing a fluidic motor according to the invention being used to skim oil etc. off the surface of water.

Figure 12 is a sectional end elevation showing the arrangement of four fluidic motors according to the invention arranged in series in a single manifold.

Figure 13 is a sectional side elevation of the arrangement of four fluidic motors shown in Fig. 12.

Figure 14 is a side elevation showing fluidic motors of the invention arranged in series in a pipeline.

Figure 15 is a diagrammatic elevation of the dosing of a large volume of liquid into a second substance using a fluidic motor according to the invention.

Figure 16 is a diagrammatic elevation of the dosing of a small volume of liquid into a second substance using a fluidic motor according to the invention.

Figure 17 is a rear elevation of a tractor dosing water with liquid fertiliser and spraying it onto the ground using fluidic motors according to the invention.

Figure 18 is a side elevation of a boat propelled by a fluidic motor according to the invention.

Figure 19 is a perspective view of a Remotely Operated Vehicle (ROV) using fluidic motor propulsion according to the invention.

Figure 20 is sectional detail of a debris collection box for use with the ROV of Fig. 19.

Figure 21 is a sectional elevation of a part of a nuclear flask storage pond.

Figure 22 is a sectional elevation of a fluidic motor floating freely in a slurry lagoon.

In the following description the same reference numeral is used for like parts fulfilling identical functions.

A fluid is defined as a liquid or a gas and the mixing of two fluids may be used to provide a pumping effort. Referring to Fig. 1, a fluidic motor 1 consists of an element 2 surrounded by two housing members 3 and 4. Conventional 'O' seals 5 in grooves are shown, but these are not strictly necessary in all applications. Through bolts 6 hold housing members 3,4 together, gripping element 2 to form a compact unit 1, as shown in Fig. 1. The element 2 is a cylindrical member with a hollow central core 11. An annular chamber 9 is machined into the outer circumference of element 2 and a plurality of holes 10 drilled at an angle, as shown, from the annular chamber into hollow central core 11. The holes are drilled at an angle θ to the radial plane in the axial direction as shown in Fig. 1. An angle of 30 - 40° for θ has been found to be most suitable for general pumping applications.

Fig. 2 is a normal sectional view through element 2 shown in Fig. 1. Here the holes 10 are indicated by dotted lines 22. A plurality of six holes 10 is shown in the example in

Fig. 2, but a greater or smaller number of holes 10 may be used as required. Six holes has been found to be suitable for most applications. As shown by the dotted arrows 23, the lines of the holes 22 cause the jets to enter the core 11 along the line of a projected chord. The angle at which the holes 10 (22) are drilled is shown by reference to the chord 25 which joins the exit points of holes 22B and 22C; as shown, the jet from hole 22A is directed at the midpoint 25A of projected chord 25. It will be seen from the pattern of dotted arrows 23 that the six holes 22 combine to give a symmetrical rotation to fluids ejected from holes 10.

A tapped hole 7 communicates via bore 8 with annular space 9. In an example, compressed air is fed via tapping 7 to annular space 9 and jetted 23 out via bores 10. The action of the air flowing through the plurality of directional aligned bores 10 is to create a reduced pressure in the left hand side of core 11, so that a fluid will be drawn in 31, moved axially 24 to the right through core 11 and ejected 32, thus creating a pumping action. As shown dotted, flanges 33 may be attached to the fluidic motor using longer through bolts 6, so that the fluidic motor 1 becomes an in-line pump. Clearly, the compressed air in the example is mixed with the fluid which is being pumped, but this is not usually a problem and, in many cases, it is a positive advantage as will be described hereinafter. The dimensions of the housings 3 and 4 are designed to fit standard flanges 33 so that bolts 6, on the same pitch circle diameter, are used to secure the flanges 33 and fluidic motor 1 together.

Using six holes arranged symmetrically, as shown (Fig. 2), a 50mm internal diameter pipe 57 and an air flow rate of 0.42 - 0.57m^3/min (15 - 20 cubic feet per minute) at 3 bar pressure, a fluidic motor output of 50 - 60 litres per minute was achieved. Doubling the diameter to 100mm with the same air flow but at 4 bar gave an output of 250+ litres per minute.

It is an important feature of fluidic motors that they require a minimum of maintenance. They are thus made of materials which will withstand their environment for extended periods of time without maintenance. The element 2 is preferably made of a high

quality, non-metallic material such as PTFE, or Nylatron (RTM) both of which are suitable for the engineering machining operations required to produce the final component. Housings 3 and 4 may be made of similar materials, but, as they have to be connected to pipe runs, metals are preferred and stainless steel is a suitable material for long periods of maintenance free use. Other materials, and combinations of materials, are suitable for these components and will be apparent to skilled person. Criteria which may affect the choice of material could be the corrosive and/or abrasive nature of the materials to be handled.

Fig. 3 shows a fluidic motor with a longer housing member 3 enclosing two elements 2A, 2B. Passages 12 in elements 2A and 2B, or 13 in housing 3 connect annular chambers 9A, 9B so that the single tapped connection 7 provides the fluidising means to both elements 2A and 2B. The bores 10A and 10B act together to provide an increased pumping effort. In this case, through bolts 6 are appropriately longer.

Fig. 4 shows a variation of the fluidic motor of Fig. 3, in which the elements 2B and 2C are arranged with their bores 10B and 10C pointing in opposite directions. Here, two tappings 7A and 7B are provided, so that either element may be used separately, or in sequence. Such a unit would have the equivalent of 'backflushing' facilities and could be used for controlling the flow of solids out of a hopper, where 'bridging' might occur. The design could also be used for handling slurries, where blockages in the inlet may occur. In this case, a control unit 16 may be provided, so that the flow from airline 14 may be alternated, via lines 18 or 17, to forward flow element 2B or reverse flow element 2C respectively. It is quite possible that electrical signals 15 could be sent to control unit 16 so that forward flow is maintained for, say, a minute and reverse flow 2C for 5 seconds; i.e. the fluidic motor is backflushed for 5 seconds after every minute of forward pumping to ensure that there is no build up of solids likely to cause a blockage. Control unit 16 may be close to fluidic motor 1 or remote, as indicated by symbols 20, to give the best practical arrangement.

A particular advantage of the fluidic motor is that it is virtually maintenance free and can be controlled remotely via a central pump or compressor which provides a process fluid for the whole plant. Non-return valves 19 are incorporated in lines 17 and 18, close to the connections 7A and 7B, so that, when not in use for pumping, the liquid or slurry in core 11 does not flow back through bores 10B, 10C into annular spaces 9B, 9C or lines 17, 18.

Referring to Fig. 5, the principle operation of the fluidic motor will now be described. Compressed air 26 is supplied to annular chamber 9 and is ejected via bores 10 as small bubbles 28. The bubbles emerge with a velocity 27, as shown, which includes an axial component 27A and a radial/circumferential component 27B. In a typical example, air 26 is supplied at a pressure of 3 - 4 bar; this is equivalent to the pressure at a depth of 30 - 40m. (100 - 120 feet). Assume the fluidic motor 1 is at the bottom of a tank containing a 10m head of water. The pressure at the inlet to bore 11 will be 1 bar (above atmospheric pressure). Bubble 28 will start to expand and the pressure in core 11, downstream of bore 10, will rise to some intermediate value, say, 2 bar. Thus, the volume of air bubble 28 will double as its pressure falls from 4 to 2 bar. Driven by its momentum 27A, the expanding bubble 28 accelerates the entrained water towards the outlet. Due the radial confines of element 2 and also because of its momentum and velocity 27A in the axial direction 24, bubble 28 may assume an elliptical shape 29. Thus, as the volume of bubble 28, 29 grows, so the fluid ahead of the bubble will be accelerated. As the bubble leaves fluidic motor 1, the pressure will drop further resulting in even more expansion 30, causing the mixture of fluids to accelerate more and creating a reduction in pressure behind bubble 30. This is indicated by the outlet flow 32 being shown as double headed arrows compared to the single headed arrows of the inlet flow 31.

Though compressed air has been instanced in the above example, a pressurised liquid can equally well be used as the fluidising medium. In this case, there will not be the same expansion of the fluidising medium (unless boiling occurs), but the same pumping action of drawing material into the core and ejecting it with the fluidising liquid will occur, as described.

Fig. 5 does not show the presence of pipes on either side of the fluidic motor, but if there was a pipe on the outlet side, the pressure in it would gradually decrease towards the outlet end and, as the pressure decreased, so the air bubbles 30 would continuously expand, thus moving the entrained fluids forward at an ever greater, more turbulent rate.

Fig. 6 shows a typical installation where a fluidic motor 1 is used to transfer a liquid from a first tank 41 to a second tank 42. A valve 36 controls the flow of liquid from tank 41 into pipe 38 to fluidic motor 1. Compressor 34, which probably provides compressed air to the whole plant, provides air through pipe 37 to motor 1. A check valve 19 is incorporated close to fluidic motor 1 so that there will be no backflow of liquid into airline 37 if valve 36 is opened before valve 35. The output from fluidic motor 1 passes via pipe 39 to tank 42. The end 40 of pipe 39 is bent over into tank 42 so that the spray caused by the release of the air from the liquid is directed downwards into tank 42. Symbol 20 indicates an extended pipe run.

As indicated by the spray from the end 40 of pipe 39, the compressed air in fluidic motor 1 produces a considerable output velocity. This produces a reaction at the outlet, e.g. 40. This reaction can be used to advantage. Fig. 7 shows a large tank, which may be used for storing a suspension prone to settling. A stirrer 46 has a fluidic motor 1 at each end. Air is supplied down hollow shaft 44 and radially through pipes (not shown) in stirrer 46 to each motor 1. As shown in the plan view, Fig. 8, the efflux from the two motors causes stirrer 46 to rotate 47. Thus, the whole of the floor of tank 43 is swept by the stirring bar 46 to maintain the whole contents in suspension. The air emanating from motors 1 will further increase the turbulence in the tank and help to maintain the uniformity of the suspension.

Fig. 9 shows a fluidic motor at the bottom of a deep well. If the water level is more than about 5m below ground level, extraction via a pump at ground level is a problem and, to remove water at any significant rate, requires the pump to be in the well. If the water level fluctuates, the best place for the pump is under the water near the bottom

of the well, as shown. This is an ideal application for a fluidic motor 1. Outlet pipe 38 and air line 37 would be secured together and used to lower fluidic motor 1 into the well, as shown. When air is supplied 37, water is drawn in and pumped up pipe 38 to a tank (not shown). An advantage of this design is that it is portable and the air can be supplied by a portable diesel compressor; it is thus suitable for use in developing countries, where a single system could be moved around and used for the separate wells serving a number of villages.

Fig. 10 shows the fluidic motor 1 mounted underneath a hopper 49 full of granular material 50. An outlet valve 51 controls the flow of the granules into, say, a bagging apparatus. As shown, a 'bridge' 50A has formed at the bottom of the hopper. For this application a fluidic motor with backflushing facilities, such as shown in Fig. 4 is preferred. Forward flow would be maintained for the majority of the time, with regular bursts of reverse flow to disrupt any bridging 50A and thus ensure a smooth flow of granules 50 from hopper 49.

Because the fluidic motor is ideally suited to submerged operation, it can be used for skimming oil films off the surface of water. Fig. 11 shows a 'boat' 55 carrying a fluidic motor 1 supported by buoyant means 52. A weir 54 allows the surface water and oil film to be drawn into the boat and removed by fluidic motor 1 via pipe 39 into a waste tank 42. As with the well design, the airline 37 is secured to pipe 39.

Where larger volumes of liquid have to be transferred, fluidic motors having larger internal diameters can be used. An alternative is to use a number of smaller motors in parallel. Fig. 12 shows four such motors mounted in a manifold 59 acting together to produce a larger output though with essentially the same head as produced by a single motor. Fig. 13 is a sectional side elevation of the section shown in Fig. 12. To generate a greater head, the fluidising air pressure can be increased or, alternatively, fluidic motors may be used in series, as shown in Fig. 14.

Dosing is a frequent requirement in the processing of substances. This may be to cause a reaction to occur, simple dilution or for more precise purposes, such as pH control. Fig. 15 shows the addition of a large volume of liquid 61 in a tank 60. Compressed air is fed via pipe 37 to tank 60 and drives liquid 61 through orifice plate 62 into fluidic motor 1. As compressor 34 maintains a constant pressure, a uniform flow will be created in pipe 56, so that an appropriately sized orifice plate can be pre-selected to deliver the required dosage of additive 61. Where a smaller volume of additive is required, this can be metered in as shown in Fig. 16. Here, the additive 61 is passed via a metering pump 63 into the air line 37 and thence to fluidic motor 1. The turbulence created by the entrained air in pipe 56 downstream from motor 1 will ensure that the additive 61 is uniformly distributed throughout the liquid being pumped.

A particular application of dosing is shown in Fig. 17 where a tractor is being used to spray fertiliser onto grassland . Water 65 in a tank 64 is fed to fluidic motors 1 via the action of fluidising liquid fertiliser 61 in tanks 60. Compressed air 37, from the tractor's compressor drives the fluidic motors 1 and the mixture is passed to manifold 66 and sprayed 67 onto the ground.

A further application is shown in Fig. 18 where a fluidic motor 1 is mounted in the hollow keel 69 of a boat 68. The boat would either have a diesel driven compressor or a compressed air cylinder to provide the fluidising air. If the fluidic motor 1 is placed in the foreword part of the keel 69, the air bubbles discharged will tend to act as a 'cushion' between the hull 68 and the water so reducing the resistance to motion of the boat through the water.

Fig. 19 shows the application of the fluidic motor to a Remotely Operated Vehicle (ROV) controlled through an umbilical connection 74. The ROV consists of an inlet pipe 71 extending from the housing 3, with wings 72 and a control/buoyancy box 73 The umbilical connection 74 carries air, connections to a closed circuit television (CCTV) and an electronic control cable. Under the control of the umbilical 74, propulsion air is provided and the ROV may be directed via additional steering jets 75

in wings 72 using the CCTV to guide it round obstacles. A buoyancy chamber in control box 73 is used to adjust the depth at which the ROV operates. A typical application for this could be in nuclear flask storage ponds 77 (Fig. 21) where the ROV could be steered over weirs 79 and around stacks of flasks 80. The CCTV would be used for close underwater inspection of the outsides of the flasks 80 for possible signs of corrosion, etc. Though a flow of water is maintained through ponds 77, flakes of rust 78 may occasional fall off. These could be collected by the ROV using a debris collection box 76 (Fig. 20). As shown, pipe 71A is moved towards the rust flake 78 which is drawn into box 76 and deposited 78A. The influx 31 passes out through pipe 71, via an optional wire mesh filter 81. Such a collection means would allow large items of debris 78, which would not otherwise be removed via the circulation system, to be cleared.

Fig. 22 shows the application of fluidic motor 1 to a slurry lagoon on a farm. Here the solid 85 and liquid 84 waste from milking parlours etc. is passed into lagoons for holding and treatment purposes. Here the fluidic motor assembly floats 52 freely on the surface 53 of the liquid 84. An inlet pipe 71 extends well below the surface 53 of the water and draws in 31 solids 85 with the liquid 84. The efflux 32 is sprayed upwards through pipe 82 back into the lagoon. An optional deflector cap 83 may be provided. The purpose of this application is twofold. Firstly, it maintains the solids 85 in suspension and secondly it assists with the aeration of the slurry which has a considerable biological oxygen requirement before it can be disposed of, e.g. to fertilise the land. Environmental regulations demand that slurries must be treated before disposal onto land to avoid polluting runoff into water courses or noxious smells. The aeration, caused both by the addition of compressed air via pipe 37 and as spray 32 passes through the air, is essential to the treatment of slurries before environmentally acceptable disposal.

The fluidic motor unit shown in Fig. 22 floats freely on the surface 53 and is allowed to 'meander' at will so that the whole of a large lagoon can be kept aerated and in suspension. If some areas are missed, the unit can be pulled, using pipe 37 or a rope

(not shown), to that area of the lagoon. If required, a system of ropes could be provided to move the unit in a predetermined pattern over the whole surface of the lagoon.

Fluidic motors may also be used to aerate water, particularly for commercial fish farms. In such an application (not shown), a fluidic motor(s) 1 would be fixed near the bottom of the tank and a continuous, low rate of air supplied. This will generate a slow circulatory flow and the rising bubbles will add to the dissolved oxygen content so breeding healthy fish. Though a grille would be placed over the inlet to stop large fish getting sucked into the fluidic motor, small fish would pass through core 11 without harm; in fact, there are indications that the fish might even enjoy the experience!

Fluidic motors according to the invention may be used for all pumping operations. In addition to the instances given, other examples are for fountains, sprays or jets, aeration, etc. A particular advantage, when pumping slurries, is that the great turbulence created by the expansion of air bubbles acts to inhibit the settling of solids in the pipework, e.g. near bends, and to dislodge any solids which may have settled, e.g. between periods of pumping.

IP108

What we claim is:-

1. A fluidic motor comprising:-

   i) a passageway having a longitudinal axis and having an inlet end and an outlet end;

   ii) an annular member surrounding said passageway and having a plurality of bores extending through said annular member into said passageway, said bores being;

      a) inclined at an angle to said longitudinal axis of said passageway; and

      b) inclined at an angle to a projected radius of said passageway; and

   iii) means to pass a fluid through said bores and eject it into said passageway;

characterised in that the ejection of said fluid through said bores into said passageway causes material to be drawn into said passageway through said inlet end and be pumped out of said passageway through said outlet end.

2. A fluidic motor, as claimed in claim 1, wherein said fluidic motor is mounted in a housing.

3. A fluidic motor, as claimed in claim 2, wherein said housing is adapted to be secured to other member(s).

4. A fluidic motor, as claimed in claim 3, wherein said other member(s) are flanges in a piping system.

5. A fluidic motor, as claimed in claim 3, wherein said other member(s) are parts of a structure(s).

6. A fluidic motor as claimed in any preceding claim wherein said means to pass said fluid through said bores is a tapping in said housing communicating with an annular space surrounding all or part of said annular member.

7. A fluidic motor as claimed in claim 6, wherein seals are provided to maintain said fluid separate from said passageway prior to ejection through said bores.

8. A fluidic motor as claimed in claim 7, wherein a plurality of said annular members are incorporated around said passageway.

9. A fluidic motor as claimed in claim 8, wherein all the bores of said plurality of annular members are arranged to point in a single direction.

10. A fluidic motor as claimed in claim 8, wherein the bores of at least one of said plurality of annular members are aligned to face said inlet end of said passageway.

11. A fluidic motor as claimed in any previous claim, wherein separate means are provided to supply and pass said fluid through said bores of each one of said plurality of annular members.

12. A fluidic motor as claimed in claim 11, wherein said separate means are provided to supply and pass said fluid through said bores of said annular member(s) pointing towards said inlet end of said passageway and through said bores of said annular members pointing towards said outlet ends of said passageway.

13. A fluidic motor as claimed in claims 11 or 12, wherein means are provided to alternate the supply of said fluid to each of said (plurality) of annular members in a random fashion, or in a predetermined cycle

14. A fluidic motor as claimed in any previous claim, wherein said passageway is in the form of a hollow cylinder.

15. A fluidic motor as claimed in claim 14, wherein said fluid ejected through said bores is a gas.

16. A fluidic motor as claimed in claim 14, wherein said fluid ejected through said bores is a liquid.

17. A fluidic motor as claimed in claims 15 or 16, wherein said material to be drawn into and pumped out of said passageway is a fluid(s).

18. A fluidic motor as claimed in claims 15 or 16, wherein said material to be drawn into and pumped out of said passageway is a granular solid.

19. A fluidic motor as claimed in claims 15 or 16, wherein said material to be drawn into and pumped out of said passageway is a mixture of a solid in a fluid.

20. A fluidic motor as claimed in any previous claim, wherein the mixing of said fluid passing through said bores with said material in said passageway due to the pumping action, causes a physical and/or chemical change to occur in, or between, the two substances.

21. A fluidic motor as claimed in any previous claim, wherein a plurality of said fluidic motors is arranged in parallel to provide an increased throughput.

22. A fluidic motor as claimed in any previous claim, wherein a plurality of said fluidic motors is arranged in series to provide an increased head.

23. A fluidic motor as claimed in any previous claim, wherein the efflux from said outlet of said fluidic motor is used to provide motive power for said fluidic motor and any item(s) attached thereto.

24. A fluidic motor as claimed in claim 23, wherein said efflux is used to drive a stirrer attached to said fluidic motor.

25. A fluidic motor as claimed in claim 23, wherein said efflux is used to provide the motive power for a water borne craft.

26. A fluidic motor, as claimed in claim 23, wherein said efflux is used to provide the motive power for a remotely operated vehicle.

27. A fluidic motor, as claimed in claim 26, wherein said remotely operated vehicle is operable underwater.

28. A fluidic motor, as claimed in any previous claim, which is used to keep solids in a solid - liquid suspension.

29. A fluidic motor, as claimed in any previous claim, which is supported by means floating on the surface of the liquid being pumped by said fluidic motor.

30, A fluidic motor, as claimed in any previous claim, wherein the fluidising medium is air and said air is used for the purposes of aeration of the liquid, or suspension, being pumped

31. A fluidic motor as claimed in any previous claim, wherein a non-return valve is incorporated in said means to pass said fluid through said bores so that backflow from said passageway into said bores cannot occur when said means to pass said fluid through said bores is not activated.

32. A fluidic motor as claimed in any previous claim, which may be used in a submerged environment and supplied with said fluid to pass through said bores by remote means.

33. A fluidic motor as claimed in claim 32, wherein said efflux from the submerged fluidic motor is carried away from said fluidic motor via a piping means.

34. A fluidic motor, as claimed in any previous claim, as described in the attached text with reference to the attached figures.

IP108C

The Patent Office

21

Application No: GB 9611037.4
Claims searched: 1-34

Examiner: Brian Denton
Date of search: 29 August 1996

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F1E

Int Cl (Ed.6): F04F 5/00 5/02 5/10 5/12 5/24 5/26 5/42 5/44 5/46

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2210280 A	(BARRETT HAENTJENS) whole document but especially Figures 1, 3 and 3a	1-9 11 14-20 22 28 30
X	GB 1301678	(THE UDYLITE CORP) whole document, especially Figures 2, 2a,2b, 2c,25, 25a, 25b	1-6 8 9 11 14-20 22 28 30
X	GB 648004	(VENTURA) whole document	1-6 8 9 11 14-2022 28 30 32 33
X	EP 0196764 A1	(IDC KABUSHIKI) note particularly Figures 11 and 15	1-6 8 9 11 14-20 22 28 30
X	EP 0181135 A2	(NORDSON CORP) whole document, noting particularly Figures 3 and 4	1-9 11 14-20 22 28 30 32 33
X	US 4028009	(GUDZENKO ET AL) whole document	1-6 8 9 11 14-20 22 28 30

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.